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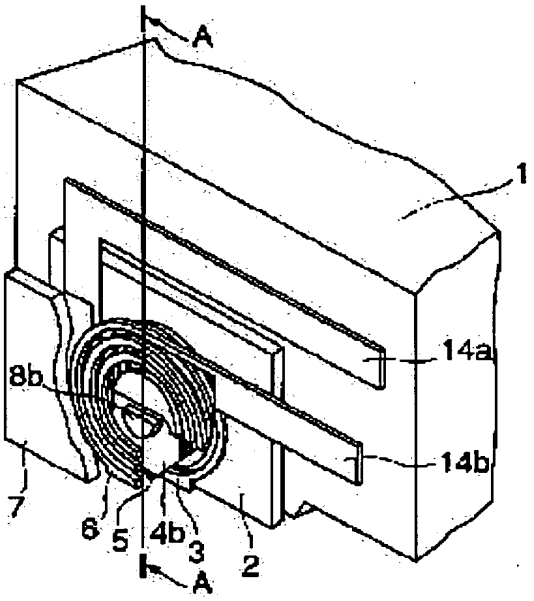
## (54) THIN FILM SINGLE MAGNETIC POLE MAGNETIC RECORDING HEAD

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a thin film signal magnetic pole magnetic recording head high in recording sensitivity and easy in production.
SOLUTION: This thin film signal magnetic pole magnetic recording head is composed of a main pole thin film 5 of a soft magnetic thin film, thin film conductor coils 3 and 6, and a magnetic core (2 and 7) of prescribed soft magnetic materials, and has at least two or more sets of the loop-shaped spiral shape thin film conductor coil whose number of turns 1 ternes. These thin film conductors coils 3 and 6 are disposed on both sides in the film thickness direction of the main pole thin film 5, and are formed so that two thin film conductor coils 3 and 6 disposed between the both sides in the film thickness direction of the main pole thin film 5 are connected or not connected to each other at one place by using the conventional technique. Consequently, the front end of the main pole film is excited, then the magnetic head excellent in recording sensitivity and hardly being affected by the external magnetic field is easily manufactured.

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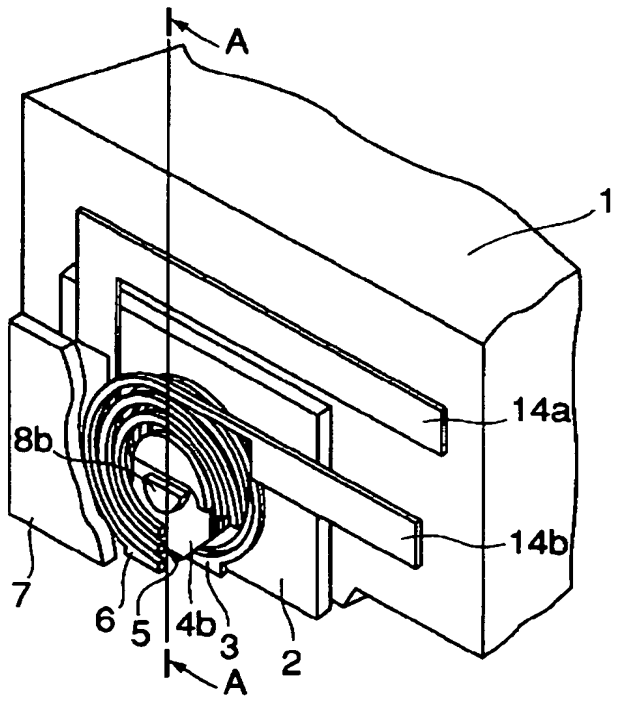
(54)【発明の名称】薄膜単磁極磁気記録ヘッド

(57)【要約】
【課題】　作製が容易で記録感度が高い薄膜単磁極磁気記録ヘッドを提供する。
【解決手段】　この薄膜単磁極磁気記録ヘッドは、軟磁性薄膜の主磁極薄膜５と、薄膜導体コイル３，６と、所定の軟磁性材料の磁気コア(２，７)から構成され、ループ形状で巻数が１ターン以上の渦巻き状薄膜導体コイルを少なくとも二組以上を有し、これら薄膜導体コイル３，６は主磁極薄膜５の膜厚方向の両側に配置され、且つ主磁極薄膜５の膜厚方向の両側間に配置された二つの薄膜導体コイル３，６同士の接続が一箇所で成されるか又は接続されないように従来技術を用いて作成する。その結果、主磁極膜先端を励磁することにより、記録感度の優れた、しかも外部磁界の影響を受けに難い磁気ヘッドを容易に作製できる。



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【特許請求の範囲】

【請求項１】　軟磁性薄膜から成る主磁極薄膜と、薄膜から成る薄膜導体コイルと、軟磁性材料から成る磁気コアと、から構成される薄膜単磁極磁気記録ヘッドにおいて、

略ループ形状を成す巻数が１ターン以上の渦巻き状薄膜導体コイルを少なくとも二組以上有し、

上記渦巻き状薄膜導体コイルは、上記主磁極薄膜の膜厚方向の両側に配置され、且つ薄膜導体コイル同士の上記主磁極薄膜の膜厚方向両側間での接続が一箇所で成されるか、又は接続されないことを特徴とする薄膜単磁極磁気記録ヘッド。

【請求項２】　軟磁性薄膜から成る主磁極薄膜と、薄膜から成る薄膜導体コイルと、軟磁性材料から成る磁気コアと、から構成される薄膜単磁極磁気記録ヘッドにおいて、

主磁極の膜厚方向の片側で渦巻き状に巻かれた薄膜導体コイルが、上記主磁極薄膜を挟んで上記主磁極薄膜の膜厚方向の対向する反対側にも配置され、それぞれの上記薄膜導体コイルが渦巻きの略中心部分では上記主磁極薄膜の膜厚方向に互いに逆方向の磁界を発生し、当該ヘッドの記録媒体対向面付近の主磁極薄膜先端部では同極性と成る磁界を発生するように、上記薄膜導体コイルが上記主磁極薄膜の奥行き方向に対して配置され、且つそれぞれの上記薄膜導体コイルの巻線方向あるいは通電する電流の極性を与えるように構成されることを特徴とする薄膜単磁極磁気記録ヘッド。

【請求項３】　上記主磁極薄膜の厚さ方向に挟むように配置させた複数個の渦巻き形状の上記薄膜導体コイルのそれぞれの最外縁が、記録媒体に対向する当該ヘッドの最表面まで露出されているか、あるいは、この最表面までの距離が５μｍ以下の露出又は露出状態に近似する位置に形成されていることを特徴とする、請求項１又は請求項２に記載の薄膜単磁極磁気記録ヘッド。

【請求項４】　上記薄膜導体コイルとこの薄膜導体コイルの上に形成した主磁極薄膜と、さらにこの主磁極薄膜の上に形成した薄膜導体コイルの構造の上に、その既に作成された主磁極薄膜に対して記録トラックの位置を適宜シフトさせた位置に配置した主磁極薄膜と、さらに上記主磁極薄膜の上に形成した薄膜導体コイルの構造を複数回繰り返して所定の積層構造を作成することによってマルチトラック記録を可能とするように構成されることを特徴とする、請求項１又は請求項２に記載の薄膜単磁極磁気記録ヘッド。

【請求項５】　上記主磁極薄膜の膜厚を記録トラック幅とすることを特徴とする、請求項１又は請求項２に記載の薄膜単磁極磁気記録ヘッド。

【請求項６】　上記主磁極薄膜の膜厚を記録トラック幅とする磁気記録ヘッドにおいて、

上記薄膜導体コイルとこの薄膜導体コイルの上に形成した主磁極薄膜とさらにこの主磁極薄膜の上に形成した薄膜導体コイルの構造に、上記主磁極薄膜とさらにこの主磁極薄膜の上に形成した薄膜導体コイルの構造を複数回繰り返して所定の積層構造を作成することによって、マルチトラック記録を可能とするように構成されることを特徴とする、請求項５に記載の薄膜単磁極磁気記録ヘッド。

【請求項７】　上記主磁極薄膜及びこの主磁極薄膜を挟む薄膜導体コイルから成る構造が軟磁性薄膜を隣接配置することで概略包括されるような構造とすることにより、外部の浮遊磁界に対する磁気シールドの効果を持たせるように構成されることを特徴とする、請求項１又は請求項２に記載の薄膜単磁極磁気記録ヘッド。

【請求項８】　当該の薄膜単磁極磁気記録ヘッドを単独、もしくは互いに組み合わせたものを記録ヘッドとして使用し、主磁極薄膜及びそれを膜厚方向に沿って上下に挟む薄膜導体コイルから成る構造を概略包括して成る軟磁性薄膜のうち、基板側の軟磁性薄膜を上層シールドとするか、あるいは、この基板から離れた位置に在る別の軟磁性薄膜を下層シールドとし、これらの軟磁性薄膜とシールドとの間に巨大または異方性磁気抵抗効果素子、トンネル効果素子または磁気インピーダンス効果素子が形成されて、再生用ヘッドとして構成されることを特徴とする、請求項１から請求項７に記載の薄膜単磁極磁気記録ヘッド。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、磁気記録再生装置に用いられる磁気記録ヘッドに係わり、特に垂直磁気記録方式での記録に適した薄膜単磁極磁気記録ヘッドに関する。

【０００２】

【従来の技術】近年の種々ある情報記録方式の中でも、磁気記録方式は、その高速性、大記録容量、高信頼性およびコスト等の面において他の方式よりも優れている点が多く、幅広い分野に用いられている。この磁気記録方式の記録密度は近年では毎年２倍前後と著しく向上しているが、現在主に用いられている長手記録方式では、記録磁化が記録媒体の面内方向に向いているため、高記録密度では反磁界の影響が大きく、今後更に要求されるであろう高記録密度の実現は原理的に困難である。これに対して、記録磁化が記録媒体面の法線方向すなわち垂直方向を向いている垂直磁気記録方式においては、長手記録方式よりも更に高い記録密度でも安定して情報が記録されるため、より高い記録密度の実現が期待できる。

【０００３】この垂直磁気記録方式では、その用いる磁気ヘッドと磁気記録媒体との組合せによって、大きく二つの磁気ヘッド・記録媒体系に分けることができる。一つは磁気ヘッドに従来の長手記録方式と同様なリングヘッドと垂直磁化記録膜の単層膜媒体を用いる系である。

この系の場合は、磁気ヘッドが従来技術のものをそのまま用いることが可能であり、現在の長手記録方式から垂直磁気記録方式への技術的な移行が行いやすいものの、このリングヘッドでは充分な垂直磁界を発生することができず、垂直磁気記録方式の優れた高密度記録特性を充分に引き出すことは困難であると考えられる。

【０００４】一方、もう一つの系としては、磁気ヘッドに単磁極ヘッドを用い、記録媒体には垂直磁化記録膜の下層に磁気ヘッドに用いられている材料と同等な軟磁性膜を組み合わせた二層垂直磁気記録媒体を用いる系である。この系の場合には、記録媒体面におおむね垂直に配置されている主磁極膜をコイルで励磁することで、垂直方向にヘッド磁界を発生させ、更にこの主磁極膜が二層垂直磁気記録媒体の軟磁性膜と強く静磁気的に結合することによって、主磁極膜で発生したヘッド磁界が急峻で強いものとなるため、理想的な垂直磁気記録が可能である。しかしながら、現在広く使われているリングヘッドと構造が異なるために、そのヘッド構造及び製造工程を新たに見直さなければならない。

【０００５】薄膜リングヘッドの場合には、ギャップに対して片方のリングヨークの厚さとそのギャップのサイズを改良することで、単磁極ヘッドに改良することも可能である。一方、その単磁極ヘッドにおいては、図１１に示すように主磁極膜の周りにヘリカル構造の導体コイルとなる導体を配置し、更にそれらから成る導体コイルを記録媒体に対向する最表面まで露出することによって、優れた記録効率が実現できる構造が特開平１１－１１０７１７号公報に提案されている。従来の薄膜ヘッドではコイルが記録媒体に対向する最表面から奥に後退した構造が一般的であったが、この特開平１１－１１０７１７号公報に提案されたヘッドの構造では、ヘリカル構造に巻回されたコイルを記録媒体に対向する最表面まで露出させることによって、主磁極膜の先端を強く励磁し、磁束の漏洩を少なくすることで優れた記録効率を示している。

【０００６】

【発明が解決しようとする課題】しかしながら、今後、よりいっそうの高い記録密度を実現する上で用いる記録媒体に対しては、単位情報が占める割合が小さくなってもその記録情報が長時間安定であるために、垂直磁気記録方式においても長手記録方式と同様に記録媒体の保磁力を高める必要がある。またこの場合に用いる磁気ヘッドに対しては、強いヘッド磁界を発生させるものが要求される。

【０００７】このような要求を満たすには、更に強い磁界が発生可能な高い飽和磁束密度の材料を用いたり、磁気ヘッドのコイルの巻数を更に増やしたりして、薄膜ヘッドの構造改良を行なうことが考えられる。しかし、高い磁束密度を持つ材料の開発が必要であっても、材料的な限界により現状の数倍の特性をもつ材料が近い将来に開発される可能性は極めて低い。また、コイルの巻数を単純に増やすことは磁気ヘッドのインダクタンスを増大させ、高い周波数領域での磁気ヘッドの動作を制限し、高密度記録と共に重要である高い転送速度の制約となる。更に、材料の改良やコイル巻数の増加などを行っても、記録媒体対向面に近い主磁極先端まで磁束の漏洩が小さな構造でなければ、優れた磁気特性の材料としての性能を充分に利用することは難しい。

【０００８】一方、そのヘッド構造に関しては、一般的な磁気ヘッドはコイルが記録媒体に対向する最表面から後退しているために、実際に記録磁化を決定する主磁極先端の部分ではヘッド磁界が広がり、また記録能力が劣化するため、これを改善するような構造が必要となる。この問題に対しては、図１１に示すように記録媒体に対向する最表面の露出位置にコイルで主磁極膜を挟むように配置する構造が特開平１１-１１０７１７号公報に提案されている。この構造により、コイルで励磁した磁界がその分布の広がる前に記録媒体に記録できるため、少ないコイルの巻数でも効率よく記録できる。

【０００９】しかしながらこの構造では、そのコイルの巻数は二回ほどと少なく、記録時には大きな記録電流が必要であり、素子の発熱や駆動用電源回路の電流制限などの問題がある。また、この構造でコイルの巻数を増やそうとした場合、その作製工程が大幅に増大したり、コイル導体を連結させる箇所が増大し、素子の小型化を妨げたり、あるいは接触抵抗の増大や信頼性の劣化も懸念される。

【００１０】その一方で、垂直磁気記録用の単磁極磁気記録ヘッドには、一般的に外部磁界の影響を受けやすいという問題がある。これは、単磁極磁気記録ヘッドが磁気回路的に開放されている状態にあり、外部からの磁界が補助磁極などに伝搬すると、この磁界が主磁極薄膜に集中することによって、単磁極磁気記録ヘッドが非動作状態にあるにも係わらず、集中した磁界によって記録媒体の情報を消去してしまうというものである。図１２及び図１３に示す如く、直接的な外部磁界及び磁気記録媒体の軟磁性層に取り込まれた外部磁界による影響を妨害する構造がそれぞれ特開平５－１０１３４１号公報及び特開平９－１４７３１９号公報に教示されている。

【００１１】このような問題を避けるためには、これらの他にも磁気ヘッドや記録媒体の磁気的な特性の制御などが考えられるが、記録装置としての性能を維持した上でそれらを制御するには制約もある。さらに、本質的に材料上の制約も大きく、単磁極磁気記録ヘッドの実用化に向けてはその構造に磁気シールドの効果をもたせるような構造が望ましい。そこで本発明の目的は、作製が容易で、記録感度が高い薄膜単磁極磁気記録ヘッドを提供することにある。

【００１２】

【課題を解決するための手段】上記課題を解決し目的を

達成するため、本発明では次のような手段を講じている。本発明の薄膜単磁極磁気記録ヘッドの一特徴は、複数個の平面内に巻かれた構造を持つ導体コイルが主磁極薄膜をその膜厚二方向に挟むように配置し、更にその導体コイルを記録媒体に対向するそのヘッドの最表面まで露出もしくは例えば５μｍ以下で極めて露出させ、その主磁極膜に対して互いに逆極性の磁界を印加するように、その導体コイルの巻線方向及び電流の極性を与えることによって主磁極膜の先端を効率よく励磁し、さらに、その主磁極薄膜と導体コイルの全体を磁気シールドとしても働く軟磁性薄膜、即ち補助磁極で囲むという構造に形成された磁気記録ヘッドである。

【００１３】すなわち、第１の発明によれば、軟磁性薄膜から成る主磁極薄膜と、薄膜から成る薄膜導体コイルと、適宜用いられる軟磁性材料から成る磁気コアとで構成される薄膜単磁極磁気記録ヘッドであって、概略的にはループ形状を成し巻数が１ターン以上の渦巻き状の薄膜導体コイルを少なくとも二組以上有し、この渦巻き状の薄膜導体コイルが主磁極薄膜の膜厚方向の両側に配置され、且つそれら薄膜導体コイル同士の主磁極薄膜の膜厚方向両側間での接続が一箇所で成されるか又は接続されないことを特徴とする薄膜単磁極磁気記録ヘッドを提案する。

【００１４】また第２の発明によれば、同様に、軟磁性薄膜から成る主磁極薄膜と、薄膜から成る薄膜導体コイルと、適宜用いられる軟磁性材料から成る磁気コアとで構成される薄膜単磁極磁気記録ヘッドであって、主磁極の膜厚方向の片側で渦巻き状に巻かれた薄膜導体コイルが、主磁極薄膜を挟んで主磁極薄膜の膜厚方向の対向する反対側にも配置され、それぞれの薄膜導体コイルがその渦巻きの概略中心部分では主磁極薄膜の膜厚方向に互いに逆方向の磁界を発生し、ヘッドの記録媒体対向面付近の主磁極薄膜先端部では同極性と成る磁界を発生するように、その薄膜導体コイルが主磁極薄膜の奥行き方向に対して配置され、且つそれぞれの薄膜導体コイルの巻線方向あるいは通電する電流の極性を与えることを特徴とする薄膜単磁極磁気記録ヘッドを提案する。

【００１５】

【発明の実施の形態】以下、実施形態とその変形例を挙げて本発明の要旨について詳しく説明する。

（第１実施形態）図１に、本発明の第１実施形態としての薄膜単磁極磁気記録ヘッドの要部の外観を斜視図で示し、図２には、図１中の線分Ａ－Ａを含む面での断面構造を示す。但し、図１中には絶縁層を省略している。この薄膜単磁極磁気記録ヘッドは、軟磁性薄膜から成る主磁極薄膜５と、薄膜から成る第１及び第２薄膜導体コイル３，６（但し図１中には第２薄膜導体コイル６の一部を切り欠いて示す）と、所定の軟磁性材料から成る磁気コア（即ち第１補助磁極２及び第２補助磁極７、但し図１中には第２補助磁極７の一部を切り欠いて示す）とから構成されている。詳しくは、二組以上（例えば図示の如く二組）でしかも略ループ形状を成し、その巻数が１ターン以上の渦巻き状の第１及び第２薄膜導体コイル３，６を有しており、これら渦巻き状を成す第１及び第２薄膜導体コイル３，６は、主磁極薄膜５の膜厚方向の両側に配置され、さらに、その第１及び第２薄膜導体コイル３，６同士の主磁極薄膜５の膜厚方向の両側間での接続が所定の一箇所で行われるか、又は接続されていないように構成されている薄膜単磁極磁気記録ヘッドである。

【００１６】また、この薄膜単磁極磁気記録ヘッドは図２に示すようにヘッドの各部位が積層構造で形成されている。概略的には、スライダ１を基板として、まず第１補助磁極２を形成し、続いて第１薄膜導体コイル３、第１主磁極増厚用薄膜４ａ、主磁極薄膜５、第２主磁極増厚用薄膜４ｂ、第２薄膜導体コイル６、そして第２補助磁極７が順次、保護膜としての非磁性絶縁層１０を介してそれぞれ積層形成される。

【００１７】このような薄膜単磁極磁気記録ヘッドにおいては、軟磁性薄膜より成る主磁極薄膜５と略平行な平面内に巻かれている複数のスパイラル構造の第１及び第２薄膜導体コイル３，６が主磁極薄膜をその膜厚を挟んで積層され、これらの第１及び第２薄膜導体コイル３，６が互いに逆極性の磁界を発生するように、第１及び第２薄膜導体コイル３，６の巻線方向もしくは記録電流の極性を設定する。これにより発生する磁界は、導体コイル中心から離間した位置で主磁極薄膜膜面内方向に平行な磁界（ここでは「カスプ型磁界」と称する）となり、主磁極薄膜５の先端部を強く磁化することができる。さらに、第１及び第２薄膜導体コイル３，６の最外巻線部の外縁を記録媒体対向面１１まで露出させることにより、特開平１１－１１０７１７号と同様に主磁極薄膜５の最先端を効率よく励磁できるようになる。

【００１８】この実施形態の巻線には、主磁極薄膜５に対して互いに逆巻きとなるスパイラル構造の第１及び第２薄膜導体コイル３，６を用い、その第１及び第２薄膜導体コイル３，６の内側の端部同士を接続部となる導体コイルピラー９を介して電気的に接合する構造としている。この構造によって、図示しない外部回路との接続に対しても特殊な配線が不要となり、容易に「カスプ型磁界」を発生することができるようになる。しかも、導体コイルの接続のための工程を煩雑にすることなく、薄膜磁気記録ヘッド全体での導体コイルの巻数を増加させることが可能であるため、記録電流に対する効率を改善できる。

【００１９】上述のようにして改善されたこのヘッドの特性を図３にグラフで表わす。例えば図３のグラフは、記録電流に対する薄膜磁気記録ヘッドの主磁極薄膜先端から発生する垂直記録媒体対向面に垂直な磁界強度の計算結果を、従来技術（特開平１１－１１０７１７号公報

の薄膜磁気記録ヘッド）のその強度の計算結果と比較したグラフである。主磁極薄膜の軟磁性薄膜の飽和磁束密度は１．２Ｔと同一値に設定し、導体コイルの巻数は、本発明の薄膜単磁極磁気記録ヘッドでは、導体コイルの幅を３μｍ、そのピッチを６μｍ、そしてそのコイルの巻数を６回とする。一方、特開平１１－１１０７１７号のヘッドの構造では、導体コイルの幅を５μｍ、その巻数を２回とすると、これらのグラフ曲線の変化により、本発明の薄膜単磁極磁気記録ヘッドのほうが記録電流に対する記録磁界の立ち上りが、従来技術に比べておよそ１．５倍ほど急峻であるという効果が生じることがわかる。

【００２０】導体コイルの巻数の増加分に見合うだけの改善は得られてはいないが、この理由としては、導体コイルピッチが広いために、主磁極薄膜５先端から離れた位置に第１及び第２薄膜導体コイル３，６の最外縁以外の部分が配置されていることに起因する。そのため記録磁界の電流効率が良くないためであるが、第１及び第２薄膜導体コイル３，６のピッチをより狭くすることでこの問題の改善が容易であると見込まれる。

【００２１】本発明の薄膜単磁極磁気記録ヘッドの詳しい作製方法とその手順は次のように行なう。基板(スライダ)１に、ＣｏＺｒＮｂアモルファスやＮｉＦｅ等の軟磁性薄膜を「スパッタ法」などにより成膜し、これを所定の形状にドライエッチングして第１補助磁極２を形成する。そしてこの第１補助磁極２の周囲にアルミナ等の絶縁層１０をスパッタリングで成膜して平坦化を行う。

【００２２】続いて、第１補助磁極２と主磁極薄膜５及び主磁極増厚用薄膜４ａとが、磁気的な結合を強めて閉磁路的な効率の良い磁気回路とするための磁極ピラー８ａを形成するためのこの部分を避けて絶縁層１０を形成する。絶縁層１０をスパッタリングで成膜したのに続いて、Ｃｕ等の比抵抗の小さな導体材料をスパッタリングし、パターニングしたフォトレジストをマスクとしてドライエッチングを行い、第１の薄膜導体コイル３を形成する。更にこの第１薄膜導体コイル３の周囲にアルミナ等の絶縁層１０を磁極ピラー８ａの部分を避けてスパッタリングによって成膜して平坦化を行う。

【００２３】また、この第１薄膜導体コイル３及び第２薄膜導体コイル６を形成する場合に、あらかじめその導体コイルのパターンと同じ溝を絶縁層１０に形成しておき、ここに「スパッタ法」や「メッキ法」などでＣｕなどの金属材料を成膜した後、研磨などを用いて平坦化を行うことで、同様に図示のような第１及び第２薄膜導体コイル３，６を形成することも可能である。

【００２４】次に、第１及び第２薄膜導体コイル３，６を互いに電気的に接続するための接続部となる導体コイルピラー９の部分と磁極ピラー８aの部分を避けて、絶縁層１０を形成する。この処理に引き続いて、ＣｏＺｒＮｂアモルファス等の軟磁性薄膜をリフトオフ等を行なうことで、磁極ピラー８ａの部分を形成する。

【００２５】上記絶縁層１０上にヘッド磁界をより主磁極薄膜５の先端付近に収束させるという目的で、第１主磁極増厚用薄膜４ａを形成する。この第１主磁極増厚用薄膜４ａの周囲も第１及び第２補助磁極２，７や第１及び第２薄膜導体コイル３，６等と同様に、パターニング後に、その周囲に第１薄膜導体コイル３と第２薄膜導体コイル６との電気的な導通を担う導体コイルピラー９の部分を避けて絶縁層１０を形成して平坦化を行う。

【００２６】また、上述のように平坦化した上記第１主磁極増厚用薄膜４ａの上に、主磁極薄膜５を形成する。この主磁極薄膜５は、前述の第１補助磁極２と同様にＣｏＺｒＮｂアモルファス膜やこれよりも更に飽和磁束密度の高いＦｅＳｉＮ膜等を成膜及びパターニングすることにより形成される。主磁極薄膜５の周囲も第１及び第２補助磁極２，７や第１及び第２薄膜導体コイル３，６等と同様にパターニング後、その周囲に絶縁層１０を導体コイルピラー９の部分を避けて形成し平坦化される。この主磁極薄膜５の上層には第２主磁極増厚用薄膜４ｂを形成する。この第２主磁極増厚用薄膜４ｂは、レジストをパターニング後にＣｏＺｒＮｂアモルファス膜等の軟磁性膜をスパッタする「リフトオフ法」を用いて形成される。

【００２７】主磁極薄膜５及び第２主磁極増厚用薄膜４ｂの形成後には、絶縁層１０を導体コイルピラー９の部分と磁極ピラー８ｂの部分を避けて形成する。この処理に引き続いて、Ｃｕ等の導体材料をリフトオフ等を行なうことで導体コイルピラー９の部分を形成する。続いて、第２薄膜導体コイル６とその周囲の絶縁物による平坦化を、磁極ピラー８ｂの部分を避けて第１薄膜導体コイル３とその周囲の絶縁層１０の形成と同様にして形成する。これにより第１薄膜導体コイル３と第２薄膜導体コイル６とが電気的に接続される。

【００２８】さらに、全体に絶縁層１０を磁極ピラー８ｂの部分を避けて形成後、ＣｏＺｒＮｂアモルファス膜等の軟磁性膜をリフトオフ等を行なうことで、磁極ピラー８ｂを形成する。引き続いて、第２補助磁極７を前述の第１補助磁極２の形成と同様にして形成する。なお、第１及び第２補助磁極２，７は応用例に応じて省略することも可能である。最後に、第１薄膜導体コイル３及び第２薄膜導体コイル６の各電極部としてのコイル端部１４ａ，１４ｂそれぞれにパターンメッキ等の手法を用いて端子形成を行い、アルミナ等の酸化物を保護膜（即ち絶縁層１０）としてスパッタリングで成膜することにより形成し、その後、研磨などを行なうことで端子出しを行う。

【００２９】以上の手順が、第１実施形態に例示の薄膜単磁極磁気記録ヘッドの作成方法の一例である。ここに例示した作製方法は主に薄膜ドライプロセスを用いてい

るが、通常の薄膜リングヘッドの標準的な作製プロセスに用いられるメッキプロセスや、あるいは平坦化のためのＣＭＰプロセスを適用して本発明の薄膜単磁極磁気記録ヘッドを作製することも可能である。また、本発明の薄膜単磁極磁気記録ヘッドの第１及び第２薄膜導体コイル３，６は、記録媒体に対向する最表面１１に露出して設けられているので、その第１及び第２薄膜導体コイル３，６の材料として耐食性に優れた材料を、その導体コイルの先端に露出する最外周もしくは全体に用いることも考えられる。

【００３０】なお、主磁極薄膜５と、磁気コアを成す第１及び第２補助磁極２，７との間のギャップは、記録磁界分布を考慮して適宜に決められる。この場合、このギャップの値は例示する図２中の主磁極薄膜５の左右、すなわち主磁極薄膜５の膜厚方向の上下で同じである必要はない。同様にして、第１及び第２補助磁極２，７は必ずしも磁気記録ヘッドの記録媒体対向面１１の表面に露出する必要はなく、記録磁界分布を勘案して、この磁気記録ヘッドの記録媒体対向面１１から適当な量だけ後退させて配置してもよい。

【００３１】(作用効果１)この第１実施形態では、基板に対して平行に主磁極薄膜を上下に挟むように配置されている二つのスパイラル状の薄膜導体コイルが垂直磁気記録媒体と対向する最表面に露出して成る構造によって、主磁極薄膜先端を効率よく励磁することが可能となり、高い記録感度が期待できる。そして上記のような二つのスパイラルコイルによって発生する「カスプ型磁界」の方向は、主磁極薄膜先端部において、当該薄膜と同一平面内に与えられるため、本質的に垂直記録媒体面に対して垂直な磁界を印加しやすくなる。さらに、その薄膜導体コイルがスパイラル状の構造であるため、巻数の増加も容易であり、且つ、同様の構造のコイルを有する薄膜リングヘッドからの技術的な移行も容易である。

【００３２】また、薄膜導体コイルが二つの部位に別れているため、同数の巻数をもつスパイラルコイルに比べてインダクタンスがおよそ半分に低減できるため、高周波での特性の改善も期待できる。また、主磁極薄膜及び薄膜導体コイルらから成る構造がその膜厚方向の上下に配置されている軟磁性薄膜、すなわち、この薄膜単磁極磁気記録ヘッドにおける補助磁極で概略包括されるような構造とすることにより、外部の浮遊磁界に対する磁気シールドの効果をもたせることも期待できる。

【００３３】また更に、これら補助磁極の内、基板側の第１補助磁極２である軟磁性薄膜を上層シールドとみなすことによって、現行のマージ型ＭＲヘッドと同様に、この軟磁性薄膜と別のシールドとの間に磁気抵抗効果素子を形成することによって、再生専用ヘッドと一体化することが可能である。一方、基板１から離れた位置にある上部の第２補助磁極７である軟磁性薄膜についても下層シールドとみなして、同様に再生専用ヘッドと一体化することも可能である。後者の場合には巨大または異方性磁気抵抗効果素子が作製プロセスの後半で作製されるために、そのプロセス中の熱の影響を受け難くくなり、材料の選択及びそのプロセス上の柔軟性などの面においても利点がある。

【００３４】なお、第１実施形態(図１、図２参照)に例示した構造の形態は、次に述べる変形例１～変形例４のようにも変形実施ができる。

（変形例１）図４は、第１実施形態の変形例１としての薄膜単磁極磁気記録ヘッドを構造断面図で示しており、第１主磁極増厚用薄膜、磁極ピラー及びコイルピラーを省略した場合である。つまりこの変形例１の薄膜単磁極磁気記録ヘッドは、上述の第１実施形態での構造において存在していた磁極ピラー８ａ，８ｂ、導体コイルピラー９、更には主磁極薄膜５より先に形成されていた第１主磁極増厚用薄膜４ａの作製が省略される構造を有する一例である。

【００３５】この変形例１によれば、記録感度の劣化をほとんど伴わずに、主磁極薄膜５の先端を励磁する特徴を有しつつ、第１主磁極増厚用薄膜、磁極ピラー及びコイルピラーのそれぞれを省略したために、構造が簡単となると共に、作製工程が極めて容易な薄膜単磁極磁気記録ヘッドとなる。

【００３６】ここで本発明の薄膜単磁極磁気記録ヘッドとしての特性について、実際の電磁変換特性のデータを挙げて説明する。図５には、変形例１またはこれとほぼ同等の薄膜磁気ヘッドにおける記録起磁力と再生出力の関係を、従来の薄膜単磁極ヘッド（図１０参照）と比較してグラフで示している。この比較対象のヘッドのうち、本発明の変形例１またはこれとほぼ同じ形態で製造したヘッドは、主磁極薄膜厚０．４μｍ、コイル巻数６回、主磁極薄膜材料ＣｏＺｒＮｂアモルファス単層薄膜及びこれよりも飽和磁束密度の高いＦｅＳｉＮ薄膜とＣｏＺｒＮｂアモルファス薄膜との積層膜という寸法・材質から成る薄膜単磁極磁気記録ヘッドである。

【００３７】一方は、主磁極薄膜厚１μｍ、コイル巻数１７回、主磁極薄膜材料ＣｏＺｒＮｂアモルファス単層薄膜という寸法・材質から成り、適宜に絶縁層を介して補助磁極、スパイラル構造の導体コイル及び主磁極薄膜の積層構造から構成される図１０に示すような従来構造の薄膜単磁極ヘッドである。そしてこのグラフには、これらヘッドを用いて、垂直方向の保磁力がおよそ３．５ｋ０ｅ の同一な二層垂直磁気記録媒体と組み合わせて磁気記録を行い、同一の諸元を持つ長手記録用のマージ型ＭＲヘッドを用いて再生して測定を行った記録電流と再生信号出力との変化の一例を表わしている。

【００３８】ここに表わされた特性グラフによれば、本発明の薄膜単磁極磁気記録ヘッドは、主磁極薄膜厚が薄いのにもかかわらず、従来構造の薄膜単磁極ヘッドに比べて３分の１の記録起磁力、すなわち、コイルの巻数が

６回と少ないのにもかかわらず１５mA$_{o-p}$程度という小さな記録電流で垂直方向の保磁力が３．５k0eという比較的大きな二層垂直磁気記録媒体を飽和記録できていることがわかる。

【００３９】また、図６のグラフには本発明の薄膜単磁極磁気記録ヘッドのオーバーライト特性の一例を示す。このグラフによれば、例えば、記録電流２０mA$_{o-p}$で－３０dB、４０mA$_{o-p}$で－５０dBのオーバーライト特性が得られ、実用充分なオーバーライトが可能である。このように本発明の薄膜単磁極磁気記録ヘッドは、従来提案された薄膜単磁極ヘッドに比べても、より優れた記録性能を有することがわかる。

【００４０】（変形例２）さらに次のように変形実施してもよい。図７には第１実施形態の変形例２としての薄膜単磁極磁気記録ヘッドの断面構造を示しており、これは、第２補助磁極及び第２主磁極増厚用薄膜を省略した例である。すなわち変形例２の薄膜単磁極磁気記録ヘッドは、前述の変形例１で説明した構造で、作製工程の最後の方の処理段階で作製されていた第２主磁極増厚用薄膜４ｂ及び第２補助磁極７が、図示の如くここではさらに省略されている構造を特徴とする。

【００４１】この変形例２によれば、この薄膜単磁極磁気記録ヘッドは、前述した例に比べて記録感度の多少の低下及び磁気シールド効果の減少が僅かに懸念されるものの、主磁極薄膜５の先端を励磁する特徴を有しつつ、作製工程が大幅に簡略化される。また、更に磁気コアとしての片側の第１補助磁極２の作製を省略してもよく、この省略によっていっそうの作製工程の簡略化を図る簡単な構造の実現も可能である。

【００４２】（変形例３）また図８には、前述の第１実施形態の変形例３を構造模式図で示しており、導体コイルを多層構造とした場合を示している。この変形例３の薄膜単磁極磁気記録ヘッドが有するスパイラル状の薄膜導体コイルは次のように構成されている。すなわち、主磁極薄膜５の下層に第１薄膜導体コイル３ａ，３ｂ、その上層に第２薄膜導体コイル６ａ，６ｂが、それぞれ上下に二層ずつ配置されている。

【００４３】詳しくは、前述の第１薄膜導体コイルの下層側（第１薄膜導体コイル３ａ）と上層側（第１薄膜導体コイル３ｂ）が接続部となるコイルピラー９ａを介して電気的に接続され、さらに、その第１薄膜導体コイルの上層側（第１導体コイル３ｂ）と第２薄膜導体コイル３ｂの下層側（第２薄膜導体コイル６ａ）とがコイルピラー９ｂを介して電気的に接続されている。また更に第２薄膜導体コイルの下層側（第２薄膜導体コイル６ａ）と上層側（第２薄膜導体コイル６ｂ）がコイルピラー９ｃを介して電気的に接続された構造となっている。この変形例３の場合においても、薄膜導体コイル同士の主磁極薄膜の膜厚方向の両側間での接続は、コイルピラー９ｂの部分一箇所で成されている。

【００４４】この変形例３によれば、作成工程が僅かに増えるものの、コイルの巻数を増やし、なお且つ主磁極薄膜５の先端の励磁に寄与するコイルの巻数が増えるため、いっそうの記録感度の向上が期待できる。その作成工程の増加も、薄膜磁気ヘッドの多層コイルの作成技術の流用が可能なので、技術的に大きな問題とはならない。さらに、多層化に伴う導体コイルの接合部分の個数は一個ずつ増加するものの、増えた接続部のコイルピラーは、図中のコイルピラー９ａの上にコイルピラー９ｃが形成されているように、これらコイルピラー９ａ，９ｂの膜厚方向延長線上に形成することができる。したがって、積層された第１及び第２薄膜導体コイル３ａ，３ｂ，６ａ，６ｂの接続のため余分な領域をほとんど必要としないので、多層化によるコイル数の増加が磁気ヘッド自体の小型化を妨げるようなことは特に生じない。

【００４５】またこれは、一層（巻数０．５回）増える毎に、接続部分の個数が一個ずつ増え、その増えた接続部が既に作成された接続部に電気的絶縁が可能な平面上の別の位置に作成しなければならなかった図１１に例示の従来型「先端励磁型」の薄膜磁気記録ヘッドでの多層化によるコイル巻数の増加に比べても、製造上有利である。

【００４６】（変形例４）図９（ａ），（ｂ）には、前述した第１実施形態の変形例４としての薄膜単磁極磁気記録ヘッドの断面構造と、記録媒体対向面１１から見た断面構造を示している。この変形例４の薄膜単磁極磁気記録ヘッドは、上述した変形例２の構造における主磁極薄膜５及び薄膜導体コイル６を繰り返し積層して、複数の主磁極薄膜５，５ａを設けて、マルチトラック化を図った一例である。詳しくは、図示の如く二つの主磁極薄膜５，５ａと、三つの導体コイル３，６，６ａにより２トラックのマルチトラック化を行ったものである。

【００４７】この変形例４において、主磁極薄膜５に対して互いに逆極性でほぼ同じ大きさとなるような磁界を発生するような記録電流を薄膜導体コイル３，６に加えると、主磁極薄膜５を励磁することができる。またこのとき、もう一方の主磁極薄膜５ａに働く薄膜導体コイル３，６によって励磁された磁界はほぼ打ち消し合うために、励磁する導体コイル３，６，６ａ及びこれらに流す記録電流を適宜設定することによって、任意の主磁極薄膜５又は５ａの一方のみを励磁して動作させることが可能となる。このとき、記録媒体対向面１１から見た図９（ｂ）に示す如く、主磁極薄膜５，５ｂの露出している先端をその厚さ方向で一致させず、適宜にずらすことによって、マルチトラック化が可能である。また、前述の主磁極薄膜５，５ａの露出している先端が、その厚さ方向に一致している場合、もしくは一致していない場合に関わらず、その薄膜の厚さ方向をトラック幅とすることでも、マルチトラック化を図ることが可能となる。

【００４８】（その他の変形例）なお、本発明の薄膜単磁

極磁気記録ヘッドは、上述した複数の変形例の他にも、発明の要旨を逸脱しない範囲で種々の変形実施が可能である。例えば、例示した本発明の薄膜単磁極磁気記録ヘッドに係わる各部位の形状、寸法ならびに材質等は、必要に応じて種々の変更が可能であると共に、他との適宜な組合せも可能である。また、本発明の薄膜単磁極磁気記録ヘッドは、ハードディスク装置やフレキシブルディスク装置などのディスク装置のみならず、例えば、補助磁極として用いている磁性薄膜を摺動性に優れた磁性フェライト材料などに置き換えることにより、ビデオレコーダやストリーマなどのテープ装置などで垂直磁気記録方式を用いた様々な磁気記録装置にも幅広く適用が可能である。

【００４９】以上、実施形態および複数の変形例に基づき説明したが、本明細書中には次の発明が含まれる。主磁極薄膜の厚さ方向に挟むように配置させた複数個の渦巻き形状の導体コイルのそれぞれの最外縁が、記録媒体に対向する最表面まで露出されているか、またはその最表面までの距離が例えば５μｍ以下の極めて露出に近い位置に形成されていることを一特徴とする薄膜単磁極磁気記録ヘッドを提供できる。

【００５０】導体コイルとこの導体コイル上に形成した主磁極薄膜と、更にこの主磁極薄膜上に形成した導体コイルの構造の上に、その既に作成された主磁極薄膜に対して記録トラックの位置を適宜シフトさせた位置に配置した主磁極薄膜と、更にこの主磁極薄膜上に形成した導体コイルの構造を複数回繰り返して所定の積層構造を作成することでマルチトラック記録が可能な薄膜単磁極磁気記録ヘッドを提供できる。

【００５１】また、その主磁極薄膜の膜厚を記録トラック幅と等しく設定することが一特徴である薄膜単磁極磁気記録ヘッドであり、あるいは、その主磁極薄膜の膜厚を記録トラック幅とするヘッドであり、導体コイルとこの導体コイル上に形成した主磁極薄膜と更にこの主磁極薄膜上に形成した導体コイルの構造に、主磁極薄膜と更にこの主磁極薄膜上に形成した導体コイルの構造を複数回繰り返して所定の積層構造を作成することで、マルチトラック記録を可能とするような薄膜単磁極磁気記録ヘッドも提供できる。

【００５２】さらに、主磁極薄膜及びそれを上下方向に挟む導体コイルから成る構造が軟磁性薄膜を上下に配置することで概略包括されるような構造に形成することで、外部の浮遊磁界に対する磁気シールド効果をもつような薄膜単磁極磁気記録ヘッドを提供できる。また、この薄膜単磁極磁気記録ヘッドを単独もしくは互いに組み合わせたものを記録ヘッドに採用し、主磁極薄膜及びそれを上下方向に挟む導体コイルから成る構造を概略的に包括した軟磁性薄膜のうち、基板側の軟磁性薄膜を上層シールドとするか、あるいは基板から離れた位置に在る別の軟磁性薄膜を下層シールドとして、これらの軟磁性薄膜とシールドとの間に巨大または異方性磁気抵抗効果素子、トンネル効果素子もしくは磁気インピーダンス効果素子を形成して、再生用ヘッドを構成することを一特徴とする薄膜単磁極磁気記録ヘッドを提供できる。

【００５３】

【発明の効果】本発明の薄膜単磁極磁気記録ヘッドによれば、従来技術で作成可能な構造の薄膜導体コイルを形成しこれを用いながら、主磁極膜先端を励磁することで、記録感度の優れた薄膜単磁極磁気記録ヘッドが容易に作製でき、さらに、外部磁界の影響を受けにくい薄膜単磁極磁気記録ヘッドを実現できる。つまり次のような効果が挙げられる。

【００５４】（１）　主磁極先端励磁型の構造でありながら導体コイルの巻数を増やすことが容易であり、記録感度に優れた薄膜単磁極磁気記録ヘッドを実現する上で極めて有用となる。

（２）　導体コイルが長手記録方式に用いられている薄膜リングヘッドと同様のスパイラルコイルを用いているので、薄膜リングヘッドからの技術的な移行が容易である。

（３）　主磁極薄膜及び導体コイルがリターンヨークで覆われているような構造であり、外部磁界の影響を受け難い単磁極ヘッドの構造となる。

【００５５】このように本発明によれば、従来の薄膜ヘッドと同様なコイル形状で、外部磁界にも強く、従来にも増して記録感度に優れた主磁極先端励磁型の薄膜単磁極磁気記録ヘッドを提供することが可能となる。

【図面の簡単な説明】

【図１】本発明の第１実施形態としての薄膜単磁極磁気記録ヘッドの外観を一部切欠して示す斜視図。

【図２】第１実施形態の薄膜単磁極磁気記録ヘッドの図１中の線分Ａ－Ａを含む断面で示す断面構造図。

【図３】第１実施形態の薄膜単磁極磁気記録ヘッド及び、従来の薄膜磁気ヘッドのヘッド磁界の特性を比較して示すグラフ。

【図４】第１実施形態の変形例１としての薄膜単磁極磁気記録ヘッドの構成を示す断面構造図。

【図５】図１の実施形態の薄膜単磁極磁気記録ヘッド及び先端励磁ではない従来の薄膜単磁極ヘッドにおける記録超磁力と再生出力との関係を比較して示す特性グラフ。

【図６】第１実施形態の薄膜単磁極磁気記録ヘッドのオーバーライト特性を示すグラフ。

【図７】第１実施形態の変形例２としての薄膜単磁極磁気記録ヘッドの構成を示す断面構造図。

【図８】第１実施形態の変形例３としての薄膜単磁極磁気記録ヘッドの構成を示す断面構造図。

【図９】（ａ）は、第１実施形態の変形例４としての薄膜単磁極磁気記録ヘッドの構成を示す断面構造図。

（ｂ）は、（ａ）に示す断面に直交する媒体対向面でヘ

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ッドの構造を示す断面構造図。

【図１０】従来のスパイラル構造の導体コイルで励磁する薄膜単磁極磁気記録ヘッドの断面構造図。

【図１１】従来の薄膜導体で主磁極の先端を励磁する薄膜単磁極磁気記録ヘッドの模式図。

【図１２】従来の磁気シールドを有する単磁極磁気記録ヘッドの模式図。

【図１３】従来の磁気シールドを有する単磁極磁気記録ヘッドの模式図。

【符号の説明】

１…基板(スライダ)、

２…第１補助磁極（磁気コア）、

３，３ａ，３ｂ…第１薄膜導体コイル、

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４ａ…第１主磁極増厚用薄膜、

４ｂ…第２主磁極増厚用薄膜、

５，５ａ…主磁極薄膜、

６，６ａ，６ｂ…第２薄膜導体コイル、

７…第２補助磁極（磁気コア）、

８ａ，８ｂ…磁極ピラー、

９…導体コイルピラー（接続部）、

９ａ，９ｂ，９ｃ…コイルピラー、

１０…絶縁層（保護膜）、

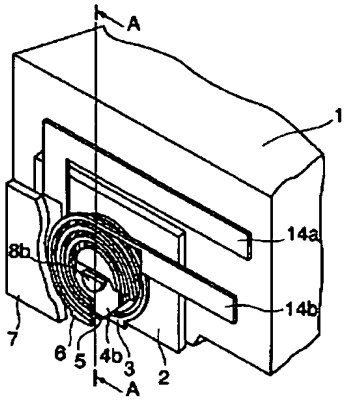
１１…記録媒体対向面、

１２，１２ａ，１２ｂ，１２ｃ…導体コイル接続部、

１３ａ，１３ｂ，１３ｃ…導体コイル用引出し電極、

１４ａ，１４ｂ…導体コイル電極部（コイル端部）。

【図１】

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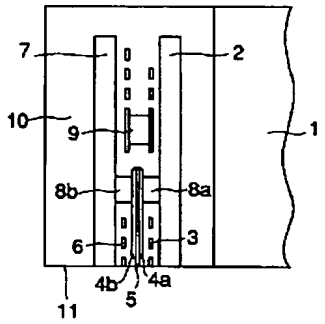


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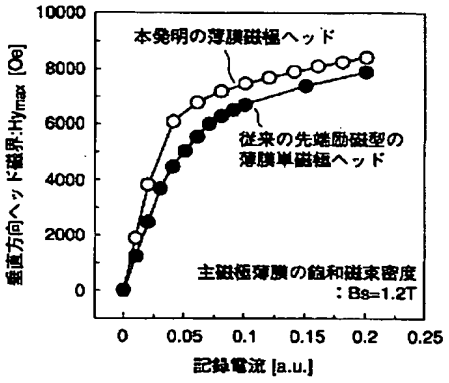


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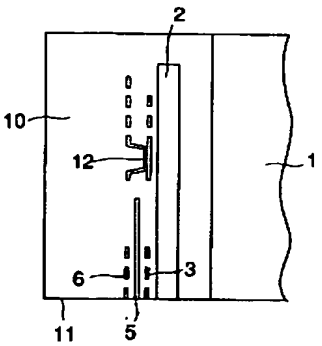


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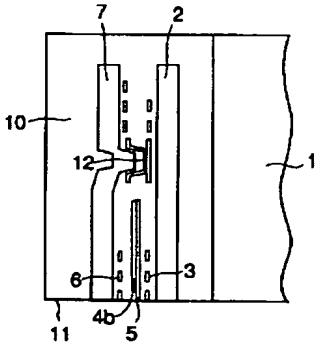


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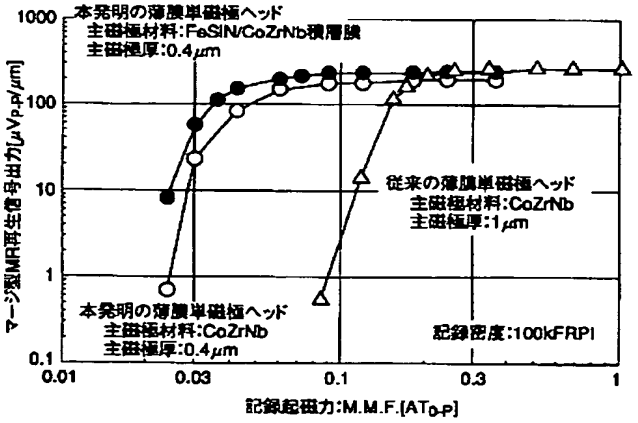

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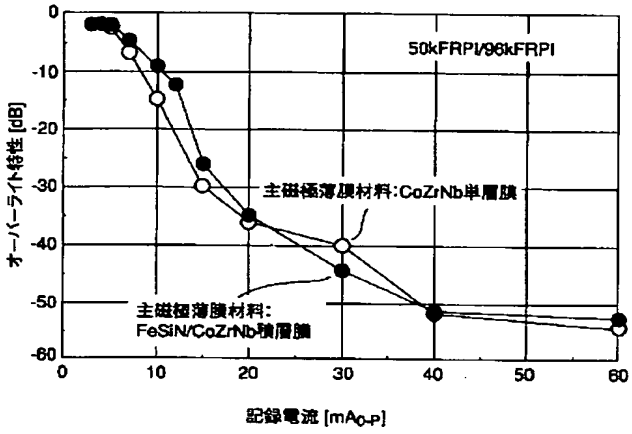


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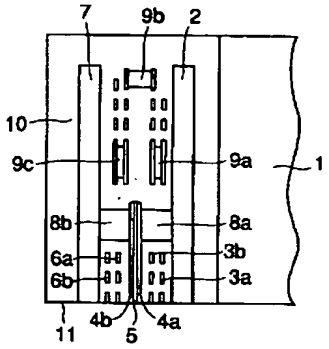
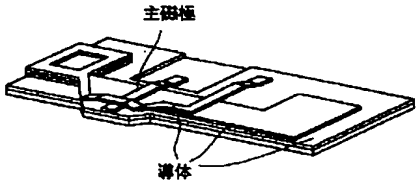



【図１１】

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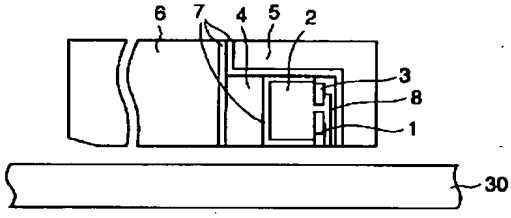


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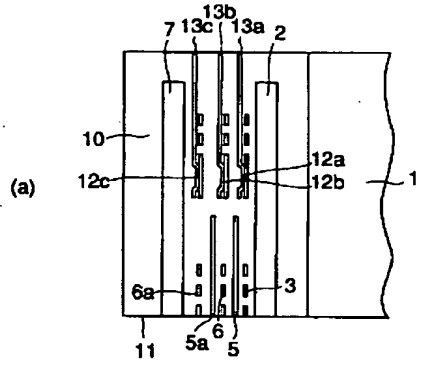


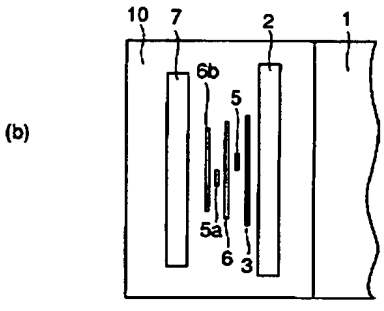


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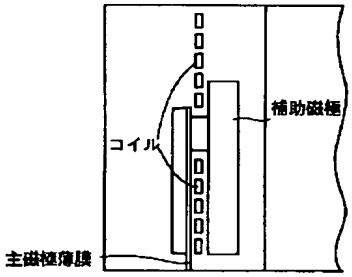


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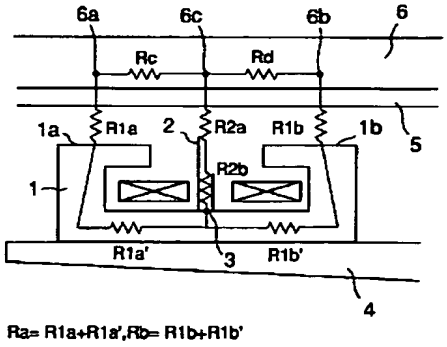


Ra= R1a+R1a',Rb= R1b+R1b'

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CLAIMS

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[Claim(s)]
[Claim 1] In a thin film single magnetic pole magnetic-recording arm head characterized by providing the following Number of turns which constitute abbreviation loop shape have at least 2 or more sets of curled form thin film conductor coils of 1 or more ******s. The above-mentioned curled form thin film conductor coil A thin film single magnetic pole magnetic-recording arm head characterized by being arranged at both sides of the direction of thickness of the above-mentioned main pole thin film, and for connection between the direction both sides of thickness of the above-mentioned main pole thin film of thin film conductor coils accomplishing by one place, or not connecting A main pole thin film which consists of a soft magnetism thin film A thin film conductor coil which consists of a thin film, and a magnetic core which consists of soft magnetic materials
[Claim 2] In a thin film single magnetic pole magnetic-recording arm head characterized by providing the following A thin film conductor coil wound around a curled form is arranged also in the opposite side where the direction of thickness of the above-mentioned main pole thin film counters on both sides of the above-mentioned main pole thin film at one side of the direction of thickness of the main pole. So that each above-mentioned thin film conductor coil may generate a magnetic field of hard flow mutually in the direction of thickness of the above-mentioned main pole thin film and may generate like-pole nature and a magnetic field which changes at a part for a vortical abbreviation core in a main pole thin film point near the record-medium opposed face of the arm head concerned A thin film single magnetic pole magnetic-recording arm head characterized by being constituted so that the above-mentioned thin film conductor coil may be arranged to the depth direction of the above-mentioned main pole thin film and the direction of a coil of each above-mentioned thin film conductor coil or the polarity of current to energize may be given A main pole thin film which consists of a soft magnetism thin film A thin film conductor coil which consists of a thin film, and a magnetic core which consists of soft magnetic materials
[Claim 3] A thin film single magnetic pole magnetic-recording arm head according to claim 1 or 2 characterized by being formed in a location which each outermost edge of two or more spiral above-mentioned thin film conductor coils arranged so that it might insert in the thickness direction of the above-mentioned main pole thin film is exposed to the maximum surface of the arm head concerned which counters a record medium, or distance to this maximum surface approximates to exposure or an exposure 5 micrometers or less.
[Claim 4] A main pole thin film formed on the above-mentioned thin film conductor coil and this thin film conductor coil, A main pole thin film arranged in a location which shifted a location of a recording track suitably to that already created main pole thin film on structure of a thin film conductor coil furthermore formed on this main pole thin film, A thin film single magnetic pole magnetic-recording arm head according to claim 1 or 2 characterized by being constituted so that multi-track record may be enabled by repeating structure of a thin film conductor coil furthermore formed on the above-mentioned main pole thin film two or more times, and creating a predetermined laminated structure.
[Claim 5] A thin film single magnetic pole magnetic-recording arm head according to claim 1 or 2

characterized by making thickness of the above-mentioned main pole thin film into recording track width of face.
[Claim 6] In a magnetic-recording arm head which makes thickness of the above-mentioned main pole thin film recording track width of face In structure of a main pole thin film formed on the above-mentioned thin film conductor coil and this thin film conductor coil, and a thin film conductor coil further formed on this main pole thin film A thin film single magnetic pole magnetic-recording arm head according to claim 5 characterized by being constituted so that multi-track record may be enabled by repeating structure of the above-mentioned main pole thin film and a thin film conductor coil further formed on this main pole thin film two or more times, and creating a predetermined laminated structure.
[Claim 7] A thin film single magnetic pole magnetic-recording arm head according to claim 1 or 2 characterized by being constituted so that an effect of magnetic shielding over an external suspension magnetic field may be given by considering as structure by which outline comprehension is carried out because structure which consists of a thin film conductor coil the above-mentioned main pole thin film and whose main pole thin film of this are pinched carries out contiguity arrangement of the soft magnetism thin film.
[Claim 8] What combined independently or mutually a thin film single magnetic pole magnetic-recording arm head of this ** is used as a recording head. [ whether a soft magnetism thin film by the side of a substrate is considered as the upper shield among soft magnetism thin films which carry out outline comprehension of the structure which consists of a thin film conductor coil which sandwiches a main pole thin film and it up and down along the direction of thickness, and change, and ] Or another soft magnetism thin film in a location distant from this substrate is considered as a lower layer shield. From claim 1 which an anisotropy magneto-resistive effect element, a tunnel effect element, or the magnetic impedance effect element is formed, and is characterized by being constituted as an arm head for playback to huge among these soft magnetism thin films and shields, or a thin film single magnetic pole magnetic-recording arm head according to claim 7

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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the thin film single magnetic pole magnetic-recording arm head suitable for especially the record by vertical magnetic recording with respect to the magnetic-recording arm head used for a magnetic recorder and reproducing device.
[0002]
[Description of the Prior Art] Also in the information recording method which has recent years variously, a magnetic-recording method has many points of excelling other methods in fields, such as the rapidity, large storage capacity, high-reliability, and cost, and is used for the broad field. Although the recording density of this magnetic-recording method improves remarkably the 2 double forward back in recent years every year, since record magnetization has turned to the field inboard of a record medium by the longitudinal recording method used for the current Lord, the effect of the anti-magnetic field in high recording density is large, and implementation of the high recording density which will be demanded further from now on is theoretically difficult. On the other hand, in the vertical magnetic recording to which record magnetization has turned, the direction of a normal, i.e., the perpendicular direction, of a record-medium side, since it is stabilized also in recording density still higher than a longitudinal recording method and information is recorded, implementation of higher recording density is expectable.
[0003] In this vertical magnetic recording, it can roughly divide into two the magnetic head and record-medium systems with the combination of that magnetic head and magnetic-recording data medium to be used. One is a system using monolayer data medium of the longitudinal recording method of the former [ magnetic head ], the same ring head, and perpendicular magnetization record film. Although the magnetic head is able to use the thing of the conventional technology as it is in the case of this system and it is easy to perform the technical shift to vertical magnetic recording from the present longitudinal recording method, perpendicular magnetic field sufficient in this ring head cannot be generated, but it is thought that it is difficult to fully pull out the high density recording characteristic which was excellent in vertical magnetic recording.
[0004] It is a system using bilayer vertical-magnetic-recording data medium which combined the soft magnetism film equivalent to the material which uses a single magnetic pole arm head for the magnetic head, and is used for the record medium as another system on the other hand at the magnetic head at the lower layer of perpendicular magnetization record film. Since the head magnetic field generated by the main pole film when a head magnetic field was generated perpendicularly and this main pole film combined with the soft magnetism film of bilayer vertical-magnetic-recording data medium in [ it is strong and ] static magnetism further by exciting with a coil the main pole film arranged in general at right angles to a record-medium side in the case of this system becomes a steep and strong thing, an ideal vertical magnetic recording is possible. However, since the ring head and structure which are used widely now differ from each other, the head structure and manufacturing process must newly be improved.

[0005] In the case of a thin film ring head, it is also possible to improve on a single magnetic pole arm head by improving the thickness and the size of a gap of one of the two's ring yoke to a gap. on the other hand, the single magnetic pole arm head is shown in drawing 11 -- as -- the surroundings of a main pole film -- the conductor of helical structure -- the conductor which arranges the conductor used as a coil and consists of them further -- the structure where the outstanding recording efficiency is realizable is proposed by JP,11-110717,A by exposing a coil to the maximum surface which counters a record medium. Although the structure which retreated at back from the maximum surface where a coil counters a record medium in the conventional thin film head was common, with the structure of the arm head proposed by this JP,11-110717,A, by exposing the coil wound around helical structure to the maximum surface which counters a record medium, the tip of a main pole film is excited strongly and the recording efficiency excellent in lessening leakage of magnetic flux is shown.
[0006]
[Problem(s) to be Solved by the Invention] However, since the recording information is long duration stability even if the rate that unit information occupies becomes small to the record medium used when realizing future more much more high recording density, it is necessary to heighten the coercive force of a record medium like a longitudinal recording method also in vertical magnetic recording. Moreover, from the magnetic head used in this case, what generates a strong head magnetic field is required.
[0007] In order to fill such a demand, it is possible to use the material of high saturation magnetic flux density which can generate a still stronger magnetic field, or to increase the number of turns of the coil of the magnetic head further, and to perform structure amelioration of a thin film head. However, even if a material with high flux density needs to be developed, a possibility that the material which has one several times the property of the present condition according to the limit like a material will be developed in the near future is very low. Moreover, increasing the number of turns of a coil simply increases the inductance of the magnetic head, it restricts actuation of the magnetic head in a high frequency domain, and serves as constraint of an important high transfer rate with high density record. Furthermore, if it is not the structure where leakage of magnetic flux is small to the main pole tip near a record-medium opposed face even if it performs amelioration of a material, the increment in coil number of turns, etc., it is difficult to fully use the outstanding engine performance as a material of magnetic properties.
[0008] In the portion at the tip of the main pole which actually determines record magnetization on the other hand since it is retreating from the maximum surface where, as for the general magnetic head, a coil counters a record medium about the head structure, the structure where a head magnetic field improves this since breadth and record capacity deteriorate is needed. The structure arranged so that a main pole film may be inserted into the exposure location on the surface of the maximum which counters a record medium as shown in drawing 11 with a coil to this problem is proposed by JP,11-110717,A. Since the magnetic field excited with the coil can record on a record medium according to this structure before that distribution spreads, it is efficiently recordable also with the number of turns of few coils.
[0009] However, with this structure, there are few number of turns of that coil as [ like two times ], and big record current is required for them at the time of record, and they have problems, such as pyrexia of an element, and current limiting of the power circuit for a drive. moreover, this structure -- the increase of the number of turns of a coil -- so -- ** -- that that production production process increases sharply when it carries out **** -- a coil -- the part with which a conductor is made to connect increases, and we bar the miniaturization of an element or are anxious also about increase of contact resistance, or deterioration of reliability.
[0010] On the other hand, there is a problem of generally being easy to be influenced of an external magnetic field in the single magnetic pole magnetic-recording arm head for vertical magnetic recordings. Although a single magnetic pole magnetic-recording arm head is in non-operating state when this is in the condition that the single magnetic pole magnetic-recording arm head is wide opened in magnetic circuit, the magnetic field from the outside spreads to an auxiliary magnetic pole etc., and this magnetic field concentrates on a main pole thin film, it will eliminate the information on a record

medium by the concentrated magnetic field. As shown in drawing 12 and drawing 13 , the structure of blocking the effect by the external magnetic field incorporated by the soft magnetism layer of a direct external magnetic field and magnetic-recording data medium is taught to JP,5-101341,A and JP,9-147319,A, respectively.

[0011] Although the magnetic head, control of the magnetic property of a record medium, etc. can be considered other than these in order to avoid such a problem, controlling them, after maintaining the engine performance as a recording device also has constraint. Furthermore, if the constraint on a material is also large and is essentially turned to utilization of a single magnetic pole magnetic-recording arm head, the structure where the effect of magnetic shielding is given to the structure is desirable. Then, the purpose of this invention is easy to produce and it is for record sensitivity to offer a high thin film single magnetic pole magnetic-recording arm head.

[0012]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem and to attain the purpose, the following means are provided in this invention. One feature of a thin film single magnetic pole magnetic-recording arm head of this invention It arranges so that main pole thin film of a coil may be pinched in the thickness 2 direction. a conductor with structure rolled in two or more planes -- furthermore, the conductor -- so that a coil may be extremely exposed by exposure or 5 micrometers or less to the maximum surface of the arm head which counters a record medium and a magnetic field of reversed polarity may be mutually impressed to the main pole film the conductor -- giving the polarity of the direction of a coil of a coil, and current -- a tip of a main pole film -- efficient -- exciting -- further -- the main pole thin film and conductor -- it is a soft magnetism thin film which commits the whole coil also as magnetic shielding, i.e., a magnetic-recording arm head formed in structure of surrounding by auxiliary magnetic pole.

[0013] Namely, a main pole thin film which consists of a soft magnetism thin film according to the 1st invention, It is the thin film single magnetic pole magnetic-recording arm head which consists of a thin film conductor coil which consists of a thin film, and a magnetic core which consists of soft magnetic materials used suitably. Accomplish loop shape roughly and number of turns have at least 2 or more sets of curled form thin film conductor coils of 1 or more ******s. or [ that this curled form thin film conductor coil is arranged at both sides of the direction of thickness of a main pole thin film, and connection between the direction both sides of thickness of a main pole thin film of these thin film conductor coils accomplishes by one place ] -- or a thin film single magnetic pole magnetic-recording arm head characterized by not connecting is proposed.

[0014] Moreover, a main pole thin film which consists of a soft magnetism thin film similarly according to the 2nd invention, It is the thin film single magnetic pole magnetic-recording arm head which consists of a thin film conductor coil which consists of a thin film, and a magnetic core which consists of soft magnetic materials used suitably. A thin film conductor coil wound around a curled form is arranged also in the opposite side where the direction of thickness of a main pole thin film counters on both sides of a main pole thin film at one side of the direction of thickness of the main pole. So that each thin film conductor coil may generate a magnetic field of hard flow mutually in the direction of thickness of a main pole thin film and may generate like-pole nature and a magnetic field which changes at a part for an outline core of the whorl in a main pole thin film point near the record-medium opposed face of an arm head A thin film single magnetic pole magnetic-recording arm head characterized by arranging the thin film conductor coil to the depth direction of a main pole thin film, and giving the direction of a coil of each thin film conductor coil or the polarity of current to energize is proposed.

[0015]

[Embodiment of the Invention] Hereafter, an operation gestalt and its modification are given and the summary of this invention is explained in detail.

(The 1st operation gestalt) The cross-section structure in the field which shows the appearance of the important section of the thin film single magnetic pole magnetic-recording arm head as the 1st operation gestalt of this invention to drawing 1 with a perspective diagram, and contains segment A-A in drawing 1 in drawing 2 at it is shown. However, the insulating layer is omitted in drawing 1 . This thin film

single magnetic pole magnetic-recording arm head consists of a main pole thin film 5 which consists of a soft magnetism thin film, 1st and 2nd thin film conductor coils 3 and 6 (however, in drawing 1 , some 2nd thin film conductor coils 6 are cut, and it is lacked and shown) which consist of a thin film, and a magnetic core (that is, in the 1st auxiliary magnetic pole 2 and the 2nd auxiliary magnetic pole 7, however drawing 1 , a part of 2nd auxiliary magnetic pole 7 is cut, and it is lacked and shown) which consists of predetermined soft magnetic materials. Moreover, abbreviation loop shape is accomplished in detail by 2 or more (for example, like illustration 2 sets) sets. The 1st and 2nd thin film conductor coils 3 and 6 which the number of turns have the curled form 1st and 2nd thin film conductor coils 3 and 6 of 1 or more ******s, and accomplish these curled forms It is the thin film single magnetic pole magnetic-recording arm head constituted as it is arranged at the both sides of the direction of thickness of the main pole thin film 5, and connection between the both sides of the direction of thickness of the 1st and 2nd thin film conductor coil 3 and the main pole thin film 5 of six comrades is further made by one predetermined place or it does not connect.

[0016] Moreover, as this thin film single magnetic pole magnetic-recording arm head is shown in drawing 2 , at least each part of an arm head is formed by the laminated structure. Roughly, by using a slider 1 as a substrate, the 1st auxiliary magnetic pole 2 is formed first, and laminating formation of the 1st thin film conductor coil 3, thin film 4for the 1st main pole thickening a, the main pole thin film 5, thin film 4for the 2nd main pole thickening b, the 2nd thin film conductor coil 6, and the 2nd auxiliary magnetic pole 7 is continuously carried out through the nonmagnetic insulating layer 10 as a protective coat one by one, respectively.

[0017] In such a thin film single magnetic pole magnetic-recording arm head On both sides of the thickness, the laminating of the 1st and 2nd thin film conductor coils 3 and 6 of two or more spiral structures currently rolled in the parallel plane is carried out in a main pole thin film. the main pole thin film 5 which consists of a soft magnetism thin film, and abbreviation -- The polarity of the direction of a coil of the 1st and 2nd thin film conductor coils 3 and 6 or record current is set up so that these 1st and 2nd thin film conductor coils 3 and 6 may generate the magnetic field of reversed polarity mutually. the magnetic field which this generates -- a conductor -- it becomes a magnetic field (here, a "cusp mold magnetic field" is called) parallel to main pole thin film film surface inboard in the location estranged from the coil center, and the point of the main pole thin film 5 can be magnetized strongly. Furthermore, the tip of the main pole thin film 5 can be efficiently excited now like JP,11-110717,A by exposing the rim of the outermost coil section of the 1st and 2nd thin film conductor coils 3 and 6 to the record-medium opposed face 11.

[0018] the conductor which serves as a connection using the 1st and 2nd thin film conductor coils 3 and 6 of the spiral structure which becomes the coil of this operation gestalt with a reverse volume mutually to the main pole thin film 5 in the edges inside those 1st and 2nd thin film conductor coils 3 and 6 -- it is considering as the structure electrically joined through the coil pillar 9. According to this structure, special wiring becomes unnecessary also to connection with the external circuit which is not illustrated, and a "cusp mold magnetic field" can be easily generated now. and a conductor -- without it makes the production process for connection of a coil complicated -- the conductor in the whole thin film magnetic-recording arm head -- since it is possible to make the number of turns of a coil increase, the effectiveness over record current is improvable.

[0019] The property of this arm head improved as mentioned above is expressed with a graph to drawing 3 . For example, the graph of drawing 3 is a graph [ the count result of the reinforcement of the conventional technology (thin film magnetic-recording arm head of JP,11-110717,A) / result / perpendicular to the vertical recording data-medium opposed face generated from the main pole thin film tip of the thin film magnetic-recording arm head to record current / of magnetic field strength / count ]. the saturation magnetic flux density of the soft magnetism thin film of a main pole thin film -- the same value as 1.2T -- setting up -- a conductor -- the number of turns of a coil -- the thin film single magnetic pole magnetic-recording arm head of this invention -- a conductor -- width of face of a coil is made to 3 micrometers, and 6 micrometers and the number of turns of the coil are made into 6 times for the pitch. on the other hand -- the structure of the arm head of JP,11-110717,A -- a conductor -- when

width of face of a coil is made to 5 micrometers and the number of turns are made into 2 times, change of these graph curves shows that the effect that stand going up [ as opposed to record current in the way of the thin film single magnetic pole magnetic-recording arm head of this invention ] of a record magnetic field is steep about about 1.5 times compared with the conventional technology arises.
[0020] a conductor -- although only the improvement corresponding to the increment of the number of turns of a coil is not obtained -- as this reason -- a conductor -- since the coil pitch is large, it originates in portions other than the outermost edge of the 1st and 2nd thin film conductor coils 3 and 6 being arranged in the location distant from main pole thin film 5 tip. Therefore, although it is because the current efficiency of a record magnetic field is not good, it is expected by making narrower the pitch of the 1st and 2nd thin film conductor coils 3 and 6 that an improvement of this problem is easy.
[0021] The detailed production method and procedure of the thin film single magnetic pole magnetic-recording arm head of this invention are performed as follows. Soft magnetism thin films, such as CoZrNb amorphous ** NiFe, are formed by a "spatter" etc., dry etching of this is carried out to a predetermined configuration, and the 1st auxiliary magnetic pole 2 is formed in a substrate (slider) 1. And the insulating layers 10, such as an alumina, are formed by sputtering around this 1st auxiliary magnetic pole 2, and flattening is performed.
[0022] Then, the 1st auxiliary magnetic pole 2, the main pole thin film 5, and thin film 4a for main pole thickening avoid this portion for forming magnetic pole pillar 8a for strengthening magnetic association and considering as a magnetic circuit with sufficient closed magnetic circuit-effectiveness, and form an insulating layer 10. Dry etching is performed after having formed the insulating layer 10 by sputtering by using as a mask the photoresist which carried out sputtering of the small conductor material of specific resistance, such as Cu, and carried out patterning, and the 1st thin film conductor coil 3 is formed. Furthermore, the portion of magnetic pole pillar 8a is avoided, the insulating layers 10, such as an alumina, are formed to the perimeter of this 1st thin film conductor coil 3 by sputtering, and flattening is performed to it.
[0023] moreover, the case where this 1st thin film conductor coil 3 and the 2nd thin film conductor coil 6 are formed -- beforehand -- that conductor -- after forming the same slot as the pattern of a coil in the insulating layer 10 and forming metallic materials, such as Cu, with a "spatter", "plating", etc. here, it is also possible to form the 1st and 2nd thin film conductor coils 3 and 6 like illustration similarly by performing flattening using polishing etc.
[0024] next, the conductor used as the connection for connecting electrically the 1st and 2nd thin film conductor coils 3 and 6 of each other -- the portion of the coil pillar 9 and the portion of magnetic pole pillar 8a are avoided, and an insulating layer 10 is formed. The portion of magnetic pole pillar 8a is succeedingly formed in this processing by performing the soft magnetism thin film of CoZrNb amorphous ** for lift off etc.
[0025] For the purpose of completing a head magnetic field near the tip of the main pole thin film 5 more, thin film 4a for the 1st main pole thickening is formed on the above-mentioned insulating layer 10. the conductor which bears an electric flow with the 1st thin film conductor coil 3 and the 2nd thin film conductor coil 6 to that perimeter after patterning like [ the perimeter of this thin film 4a for the 1st main pole thickening ] the 1st and 2nd auxiliary magnetic poles 2 and 7, the 1st and 2nd thin film conductor coil 3, and 6 grades -- the portion of the coil pillar 9 is avoided, an insulating layer 10 is formed, and flattening is performed.
[0026] Moreover, the main pole thin film 5 is formed on the above-mentioned thin film 4a for the 1st main pole thickening which carried out flattening as mentioned above. This main pole thin film 5 is formed membrane formation and by carrying out patterning in a FeSiN film with still higher saturation magnetic flux density etc. rather than a CoZrNb amorphous film or this like the above-mentioned 1st auxiliary magnetic pole 2. the perimeter of the main pole thin film 5 -- the 1st and 2nd auxiliary magnetic poles 2 and 7, the 1st and 2nd thin film conductor coil 3, and 6 grades -- the same -- after patterning and its perimeter -- an insulating layer 10 -- a conductor -- the portion of the coil pillar 9 is avoided, it forms, and flattening is carried out. Thin film 4b for the 2nd main pole thickening is formed in the upper layer of this main pole thin film 5. This thin film 4b for the 2nd main pole thickening is

formed using the "lift-off method" which carries out the spatter of the soft magnetism films, such as a CoZrNb amorphous film, for a resist after patterning.
[0027] after formation of the main pole thin film 5 and thin film 4b for the 2nd main pole thickening -- an insulating layer 10 -- a conductor -- the portion of the coil pillar 9 and the portion of magnetic pole pillar 8b are avoided and formed. carrying out conductor material, such as Cu, for lift off etc. to this processing succeedingly -- a conductor -- the portion of the coil pillar 9 is formed. Then, the portion of magnetic pole pillar 8b is avoided, and flattening by the 2nd thin film conductor coil 6 and the insulating material of the perimeter is formed like the 1st thin film conductor coil 3 and formation of the insulating layer 10 of the perimeter. Thereby, the 1st thin film conductor coil 3 and the 2nd thin film conductor coil 6 are connected electrically.
[0028] Furthermore, magnetic pole pillar 8b is formed by avoiding the portion of magnetic pole pillar 8b for an insulating layer 10 to the whole, and performing soft magnetism films, such as a CoZrNb amorphous film, for lift off etc. to it after formation. Then, the 2nd auxiliary magnetic pole 7 is formed like formation of the above-mentioned 1st auxiliary magnetic pole 2. In addition, the 1st and 2nd auxiliary magnetic poles 2 and 7 can also be omitted according to an application. the last -- the coil ends 14a and 14b as each polar zone of the 1st thin film conductor coil 3 and the 2nd thin film conductor coil 6 -- it is alike, respectively and terminal formation is performed using technique, such as pattern plating, it forms by forming membranes by sputtering by using oxides, such as an alumina, as a protective coat (namely, insulating layer 10), and terminal **** is performed by performing polishing etc. after that.
[0029] The above procedure is an example of the creation method of the thin film single magnetic pole magnetic-recording arm head of instantiation in the 1st operation gestalt. the plating process used for the standard production process of the usual thin film ring head although the production method illustrated here mainly uses the thin film dry process -- or it is also possible to produce the thin film single magnetic pole magnetic-recording arm head of this invention with the application of the CMP process for flattening. moreover, the material which was excellent in corrosion resistance as a material of the 1st and 2nd thin film conductor coils 3 and 6 since the 1st and 2nd thin film conductor coils 3 and 6 of the thin film single magnetic pole magnetic-recording arm head of this invention were exposed and formed in the maximum surface 11 which counters a record medium -- the conductor -- using for the outermost periphery or the whole exposed at the tip of a coil is also considered.
[0030] In addition, the gap between the main pole thin film 5 and the 1st and 2nd auxiliary magnetic poles 2 and 7 which accomplish a magnetic core is suitably decided in consideration of record magnetic field distribution. In this case, the value of this gap does not need to be the same at the upper and lower sides of the right and left of thickness of the main pole thin film 5 in drawing 2 to illustrate, i.e., the direction of the main pole thin film 5. Similarly, it is not necessary to necessarily expose to the surface of the record-medium opposed face 11 of a magnetic-recording arm head, and the 1st and 2nd auxiliary magnetic poles 2 and 7 take record magnetic field distribution into consideration, from the record-medium opposed face 11 of this magnetic-recording arm head, may retreat only a suitable amount and may arrange it.
[0031] (The operation effect 1) With this 1st operation gestalt, according to the structure where the thin film conductor coil of the two shape of a spiral arranged so that a main pole thin film may be pinched up and down in parallel to a substrate be exposed, and grow into vertical-magnetic-recording data medium and the maximum surface which counter, it become possible to excite a main pole thin film tip efficiently, and high record sensitivity can be expected. And since the direction of the "cusp mold magnetic field" generated with the two above spiral coils is given into the same plane as the thin film concerned, it essentially becomes easy to impress a perpendicular magnetic field in a main pole thin film point to a vertical recording data-medium side. Furthermore, since the thin film conductor coil is spiral-like structure, the increment in number of turns and the technical shift from the thin film ring head which has the coil of the same structure easily are easy.
[0032] Moreover, since an inductance can decrease in one half about compared with the spiral coil which has the number of turns of the same number since the thin film conductor coil has separated to two parts, an improvement of the property in a RF is also expectable. Moreover, it is also expectable to

give the effect of magnetic shielding over an external suspension magnetic field by considering as structure by which outline comprehension of the structure which consists of main pole thin films and thin film conductor coils is carried out by the auxiliary magnetic pole in the soft magnetism thin film with which it is arranged up and down, i.e., this thin film single magnetic pole magnetic-recording arm head, of that direction of thickness.

[0033] Furthermore, it is possible like the present merge mold MR head to unite with the arm head only for playbacks by forming a magneto-resistive effect element between shields different from this soft magnetism thin film by considering that the soft magnetism thin film which is the 1st auxiliary magnetic pole 2 by the side of a substrate among these auxiliary magnetic poles is the upper shield. It is also possible to regard it as a lower layer shield also about the soft magnetism thin film which is the 2nd auxiliary magnetic pole 7 of the upper part located on the other hand in the location distant from the substrate 1, and to unite with the arm head only for playbacks similarly. In the case of the latter, huge or since an anisotropy magneto-resistive effect element is produced in the second half of a production process, also in fields, such as selection of a material, and flexibility on the process, there is an advantage in ** that it is hard to be influenced of the heat in the process.

[0034] In addition, the gestalt of the structure illustrated in the 1st operation gestalt (refer to drawing 1 and drawing 2 ) can perform deformation implementation also like the modification 1 described below - a modification 4.

(Modification 1) Drawing 4 shows the thin film single magnetic pole magnetic-recording arm head as a modification 1 of the 1st operation gestalt in structure section drawing, and is the case where the thin film for the 1st main pole thickening, a magnetic pole pillar, and a coil pillar are omitted. that is, the magnetic pole pillars 8a and 8b and conductor with which the thin film single magnetic pole magnetic-recording arm head of this modification 1 existed in the structure in the above-mentioned 1st operation gestalt -- it is an example which has the coil pillar 9 and the structure where production of thin film 4a for the 1st main pole thickening currently further formed ahead of the main pole thin film 5 is omitted.

[0035] Since each of the thin film for the 1st main pole thickening, a magnetic pole pillar, and a coil pillar was omitted, while structure becomes easy, having the feature which excites the tip of the main pole thin film 5 according to this modification 1 without hardly being accompanied by deterioration of record sensitivity, a production production process serves as a very easy thin film single magnetic pole magnetic-recording arm head.

[0036] The data of an actual magnetic parametric performance is mentioned and explained here about the property as a thin film single magnetic pole magnetic-recording arm head of this invention. As compared with the conventional thin film single magnetic pole arm head (refer to drawing 10 ), the graph shows the relation between a modification 1 or the record magnetomotive force in the thin film magnetic head almost equivalent to this, and a playback output to drawing 5 . The arm head manufactured among the arm heads for [ this ] a comparison with the modification 1 of this invention or the almost same gestalt as this is a thin film single magnetic pole magnetic-recording arm head which consists of the size and the quality of the material of the cascade screen of 0.4 micrometers of main pole thin film thickness, six coil number of turns, a main pole thin film material CoZrNb amorphous monolayer thin film and a FeSiN thin film with saturation **** density higher than this, and a CoZrNb amorphous thin film.

[0037] from the size and the quality of the material of 1 micrometer of main pole thin film thickness, 17 coil number of turns, and a main pole thin film material CoZrNb amorphous monolayer thin film in one side -- changing -- proper -- an insulating layer -- minding -- the conductor of an auxiliary magnetic pole and spiral structure -- it is the thin film single magnetic pole arm head of structure conventionally [ as shown in drawing 10 which consists of laminated structures of a coil and a main pole thin film ]. And these arm heads are used for this graph, and vertical coercive force is about 3.5 kOe(s). Magnetic recording is performed combining same bilayer vertical-magnetic-recording data medium, and an example [ output / which measured by reproducing using the merge mold MR head with the same item for longitudinal record / the record current and the regenerative-signal output ] of change is expressed.

[0038] According to the property graph with which it was expressed here, the thin film single magnetic

pole magnetic-recording arm head of this invention Although main pole thin film thickness is thin, it compares with the thin film single magnetic pole arm head of structure conventionally. The record magnetomotive force of 1/3, That is, although there are few number of turns of a coil as 6 times, it is 15mA0-p. Vertical coercive force is 3.5kOe(s) at the small record current of a degree. It turns out that the saturation record of comparatively big bilayer vertical-magnetic-recording data medium to say has been carried out.

[0039] Moreover, an example of the over-writing property of the thin film single magnetic pole magnetic-recording arm head of this invention is shown in the graph of drawing 6 . according to this graph, 20mA [ of record current ] 0-p-30dB, and the 40mA over-writing property of 0-p-50dB obtain, for example -- having -- practical use -- sufficient over-writing is possible. Thus, even if it compares the thin film single magnetic pole magnetic-recording arm head of this invention with the thin film single magnetic pole arm head by which the conventional proposal was made, it turns out that it has the more excellent record engine performance.

[0040] (Modification 2) Deformation implementation may be carried out still as follows. The cross-section structure of the thin film single magnetic pole magnetic-recording arm head as a modification 2 of the 1st operation gestalt is shown in drawing 7 , and this is the example which omitted the 2nd auxiliary magnetic pole and the thin film for the 2nd main pole thickening. That is, the thin film single magnetic pole magnetic-recording arm head of a modification 2 is the structure explained in the above-mentioned modification 1, and thin film 4for the 2nd main pole thickening b and the 2nd auxiliary magnetic pole 7 which were produced in the processing phase in the direction of the last of a production production process are characterized by the structure currently omitted further here like illustration.

[0041] According to this modification 2, a production production process is simplified sharply, this thin film single magnetic pole magnetic-recording arm head having the feature which excites the tip of the main pole thin film 5, although we are slightly anxious about the fall of some of record sensitivity, and reduction of the magnetic-shielding effect compared with the example mentioned above. Furthermore, implementation of the easy structure of omitting production of the 1st auxiliary magnetic pole 2 of one side as a magnetic core, and attaining simplification of much more production production process by this abbreviation is also possible.

[0042] (Modification 3) the modification 3 of the 1st operation gestalt of the above-mentioned [ drawing 8 ] again -- a structure mimetic diagram -- being shown -- **** -- a conductor -- the case where a coil is made into multilayer structure is shown. The thin film conductor coil of the shape of a spiral which the thin film single magnetic pole magnetic-recording arm head of this modification 3 has is constituted as follows. That is, the 1st thin film conductor coils 3a and 3b are arranged at the lower layer of the main pole thin film 5, and the 2nd thin film conductor coils 6a and 6b are arranged the bilayer every up and down at the upper layer, respectively.

[0043] A lower layer [ of the above-mentioned 1st thin film conductor coil ] and upper layer side (1st thin film conductor coil 3a) (1st thin film conductor coil 3b) is electrically connected through coil pillar 9a used as ****** in detail. Furthermore, the upper layer [ of the 1st thin film conductor coil ] and lower layer side (the 1st conductor coil 3b) (2nd thin film conductor coil 6a) of 2nd thin film conductor coil 3b is electrically connected through coil pillar 9b. Furthermore, it has the structure where the lower layer [ of the 2nd thin film conductor coil ] and upper layer side (2nd thin film conductor coil 6a) (2nd thin film conductor coil 6b) was electrically connected through coil pillar 9c. In the case of this modification 3, the connection between the both sides of the direction of thickness of the main pole thin film of thin film conductor coils is accomplished in one portion of coil pillar 9b.

[0044] although a creation production process increases slightly according to this modification 3 -- the increase of the number of turns of a coil -- carrying out -- in addition -- and since the number of turns of the coil contributed to excitation at the tip of the main pole thin film 5 increase, improvement in much more record sensitivity is expectable. Since appropriation of the creation technology of the multilayer coil of the thin film magnetic head is possible also for the increment in the creation production process, it does not pose a big problem technically, either. furthermore, the conductor accompanying multilayering -- although the number for a joint of a coil increases a piece every, the coil pillar of the

increased connection can be formed on the direction production of thickness of these coil pillars 9a and 9b as coil pillar 9c is formed on coil pillar 9a in drawing. Therefore, since an excessive field is hardly needed for the connection of the 1st and 2nd thin film conductor coils 3a, 3b, 6a, and 6b by which the laminating was carried out, especially a thing [ a thing ] the increment in the number of coils by multilayering bars the miniaturization of the magnetic head itself is not produced.
[0045] Moreover, whenever this increases further (0.5 number of turns), even if its number for a connection increases a piece every and the increased connection compares it with the increment in the coil number of turns by multilayering with the thin film magnetic-recording arm head of the conventional type "a tip excitation mold" of the instantiation to drawing 11 which had to be created to the already created connection in another location on the plane which can be insulated electric, it is advantageous on manufacture.
[0046] (Modification 4) The cross-section structure of the thin film single magnetic pole magnetic-recording arm head as a modification 4 of the 1st operation gestalt mentioned above and the cross-section structure seen from the record-medium opposed face 11 are shown in drawing 9 (a) and (b). The thin film single magnetic pole magnetic-recording arm head of this modification 4 is an example which carried out the repeat laminating of the main pole thin film 5 and the thin film conductor coil 6 in structure of the modification 2 mentioned above, formed two or more main pole thin films 5 and 5a, and attained multi-track-ization. detailed -- like illustration -- two main pole thin films 5 and 5a and three conductors -- Coils 3, 6, and 6a perform multi-track-ization of two trucks.
[0047] In this modification 4, if record current which generates a magnetic field which serves as the almost same magnitude with reversed polarity mutually to the main pole thin film 5 is added to the thin film conductor coils 3 and 6, the main pole thin film 5 can be excited. moreover, the conductor excited in order to negate mostly mutually the magnetic field excited with the thin film conductor coils 3 and 6 which work to another main pole thin film 5a at this time -- it becomes possible to excite only the main pole thin film 5 of arbitration, or one side of 5a, and to operate it by setting up suitably the record current passed to Coils 3, 6, and 6a and these. At this time, as shown in drawing 9 (b) seen from the record-medium opposed face 11, multi-track-izing is possible by not making in agreement in that thickness direction the tip which has exposed the main pole thin films 5 and 5b, but shifting it suitably. Moreover, when [ whose tip which has exposed the above-mentioned main pole thin films 5 and 5a corresponds in the thickness direction ] not in agreement [ case or ], it is not concerned, but it also becomes possible [ attaining multi-track-ization ] to make the thickness direction of the thin film into the width of recording track.
[0048] (Other modifications) In addition, deformation implementation various in the range which does not deviate from the summary of invention other than two or more modifications mentioned above is possible for the thin film single magnetic pole magnetic-recording arm head of this invention. For example, while various modification is possible for a configuration, a size, the quality of the material, etc. like each part concerning the thin film single magnetic pole magnetic-recording arm head of illustrated this invention if needed, other proper combination is possible for them. Moreover, the thin film single magnetic pole magnetic-recording arm head of this invention is broadly applicable also to various magnetic recording media using vertical magnetic recording with tape units, such as a videocassette recorder and a streamer, etc. by transposing not only disk units, such as a hard disk drive unit and flexible disk equipment, but the magnetic thin film used as for example, an auxiliary magnetic pole to the magnetic ferrite material excellent in sliding nature etc.
[0049] As mentioned above, although explained based on an operation gestalt and two or more modifications, the next invention is included in this specification. two or more spiral conductors arranged so that it might insert in the thickness direction of a main pole thin film -- the thin film single magnetic pole magnetic-recording arm head characterized [ 1 ] by exposing each outermost edge of a coil to the maximum surface which counters a record medium, or forming the distance to the maximum surface in the location very near exposure of 5 micrometers or less can be offered.
[0050] a conductor -- a coil and this conductor -- the main pole thin film formed on the coil, and the conductor further formed on this main pole thin film -- on the structure of a coil The main pole thin film

arranged in the location to which the location of a recording track was suitably shifted to the already created main pole thin film, furthermore, the conductor formed on this main pole thin film -- a thin film single magnetic pole magnetic-recording arm head recordable multi-track can be offered by repeating the structure of a coil two or more times, and creating a predetermined laminated structure.
[0051] Moreover, it is the thin film single magnetic pole magnetic-recording arm head that whose the thickness of the main pole thin film is set up equally to recording track width of face it is one feature. Or it is the arm head which makes thickness of the main pole thin film recording track width of face. a conductor -- a coil and this conductor -- the main pole thin film formed on the coil, and the conductor further formed on this main pole thin film -- in the structure of a coil a main pole thin film and the conductor further formed on this main pole thin film -- by repeating the structure of a coil two or more times, and creating a predetermined laminated structure, a thin film single magnetic pole magnetic-recording arm head which enables multi-track record can also be offered.
[0052] furthermore, the conductor which sandwiches a main pole thin film and it in the vertical direction -- a thin film single magnetic pole magnetic-recording arm head which has the magnetic-shielding effect over an external suspension magnetic field can be offered by forming in structure by which outline comprehension is carried out because the structure which consists of a coil arranges a soft magnetism thin film up and down. Moreover, what combined this thin film single magnetic pole magnetic-recording arm head of each other [ independently or ] is adopted as a recording head. Another soft magnetism thin film in the location which considered the soft magnetism thin film by the side of a substrate as the upper shield among the soft magnetism thin films which included roughly the structure which consists of a coil, or is distant from a substrate is considered as a lower layer shield. the conductor which sandwiches a main pole thin film and it in the vertical direction -- A huge or thin film [ which is characterized / 1 / by forming an anisotropy magneto-resistive effect element, a tunnel effect element, or the magnetic impedance effect element, and constituting the arm head for playback ] single magnetic pole magnetic-recording arm head can be offered among these soft magnetism thin films and shields.
[0053]
[Effect of the Invention] According to the thin film single magnetic pole magnetic-recording arm head of this invention, forming the thin film conductor coil of the structure which can be created with the conventional technology, and using this, the thin film single magnetic pole magnetic-recording arm head which excelled [ excite / a main pole film tip ] in record sensitivity can produce easily, and the thin film single magnetic pole magnetic-recording arm head which cannot be easily influenced of an external magnetic field can be realized further. That is, the following effects are mentioned.
[0054] (1) while it is the structure of a main pole tip excitation mold -- a conductor -- it becomes very useful [ it is easy to increase the number of turns of a coil, and ], when realizing the thin film single magnetic pole magnetic-recording arm head excellent in record sensitivity.
(2) a conductor -- since the same spiral coil as the thin film ring head by which the coil is used for the longitudinal recording method is used, the technical shift from a thin film ring head is easy.
(3) a main pole thin film and a conductor -- it is the structure where the coil is covered in the return yoke, and becomes the structure of a single magnetic pole arm head of being hard to be influenced of an external magnetic field.
[0055] Thus, according to this invention, in the same coil configuration as the conventional thin film head, it is strong also to an external magnetic field, and it becomes possible to offer the thin film single magnetic pole magnetic-recording arm head of the main pole tip excitation mold which was excellent in record sensitivity also compared with the former.

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[Translation done.]

* NOTICES *



1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

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DRAWINGS

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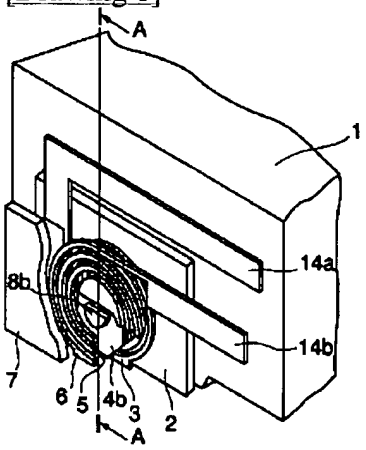
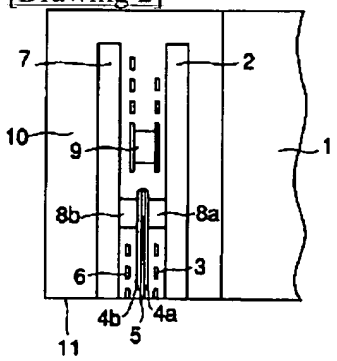
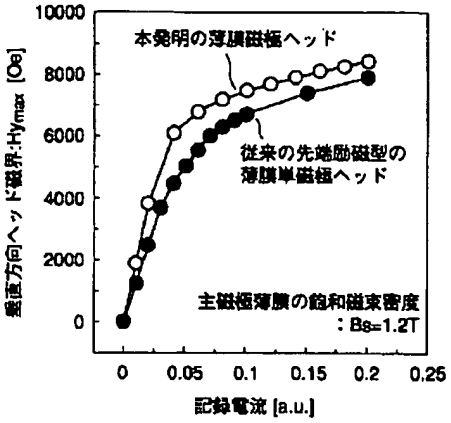
[Drawing 1]



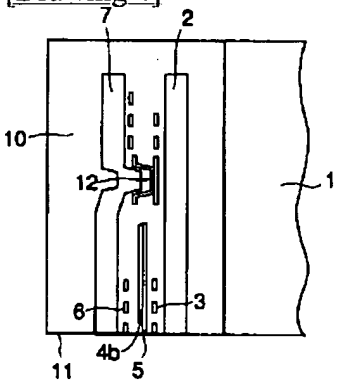

[Drawing 2]



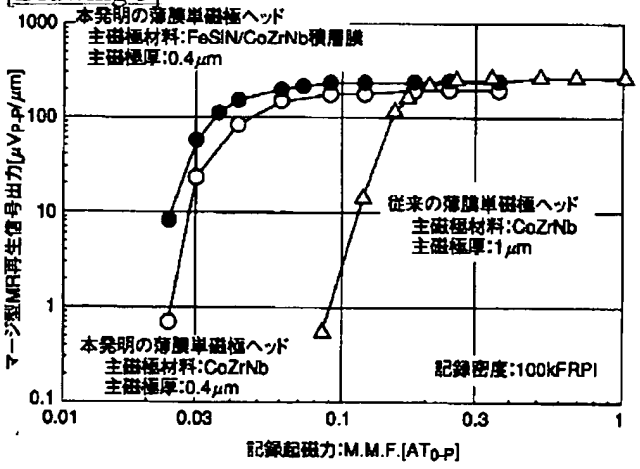

[Drawing 3]




[Drawing 4]




[Drawing 5]




[Drawing 7]